



June 22, 2017

Quick Mount PV
Attn: Marshall Green (email)
2700 Mitchell Drive
Walnut Creek, CA 94598

Job No: 11304

Job Name: Quick Mount PV On-Call Lab Testing
Walnut Creek, CA

Subject: Quick Mount PV Load Testing - L-Mount
[QMPV# 20170517-Revision E]

Mr. Green,

In accordance with your authorization, Construction Testing Services (CTS) performed load testing on the Quick Mount PV L-Mount (P/N #0151/0152). Structural tests included tensile (uplift), compressive (down force), and lateral (Parallel and perpendicular to rafter). The L-Mount was fastened to a 2"x4" Douglas Fir Rafter using a single 5/16" diameter by 4" long lag bolt. Testing was conducted in general accordance with industry standard testing procedures, including ASTM D1761-12, D2395-14, and ICC AC13.

Test Equipment

Equipment used to perform the various tests include:

- Instron 100HDX Universal Tensile/Compression Machine; Calibrated 8/23/2016
- Delmhorst BD-2100 Moisture Meter; Calibrated daily
- Quincy Lab Inc. 21-250 Oven; Calibrated 02/6/2017
- Digital Caliper AB11881; Calibrated 02/6/2017
- AE Adam PGL 30001 Scale; Calibrated 02/6/2017



- TESTING
- INSPECTION
- ENGINEERING

Sample Description

(31) 16"x16" wood test boards were delivered to our laboratory on May 30, 2017. Each specimen was made up of 2"x4" lumber, topped with 1/2" OSB, 30 lb. felt paper, and comp shingles layered to represent typical installation applications. The L-Mount was fastened to a 2"x4" Douglas Fir Rafter using a single 5/16" diameter by 4" long lag bolt. Test loads were applied directly to the L-Foot for tensile. Compressive and lateral test loads were applied to a block attached to the L-Foot to represent typical transfer of load from the rail into the L-Foot. See Figure 1 for a typical test board.

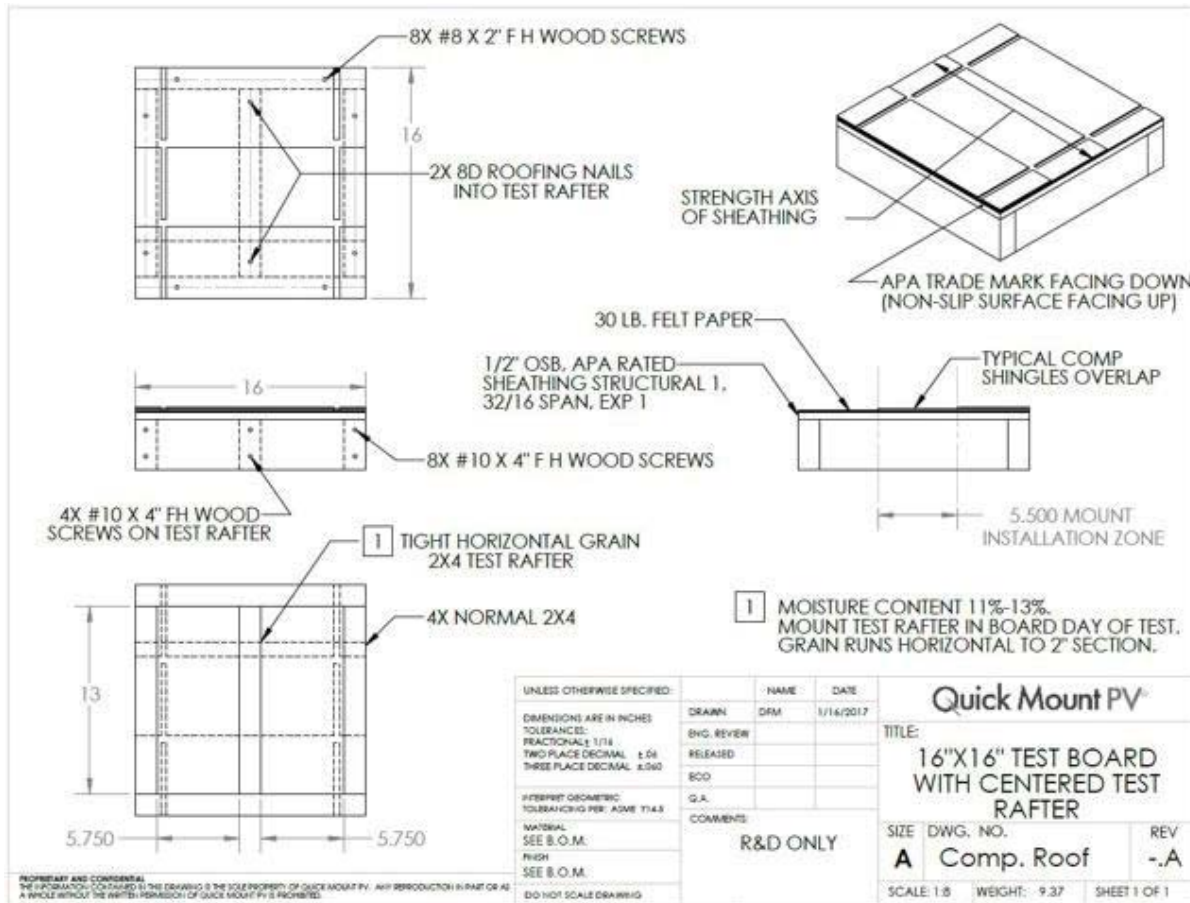


Figure 1: Typical Test Board



Structural Test Configurations and Results

Tensile (Uplift)

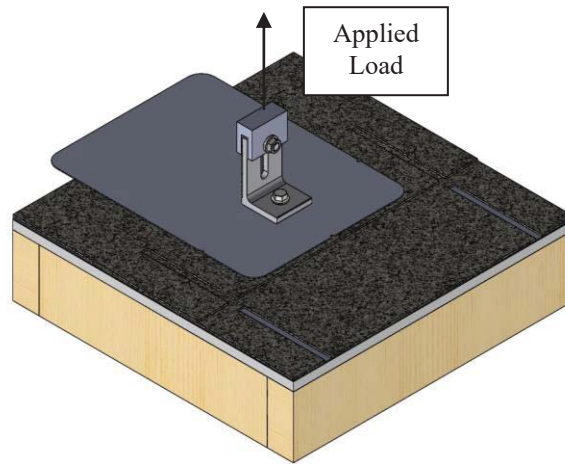


Figure 2: Tensile Load

Sample Number	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
T-1	0.5472	12.8	3546	1.2119	Lag Screw Withdrawl
T-2	0.4728	12.4	2602	0.8655	Lag Screw Withdrawl
T-3	0.4489	11.5	2405	0.8865	Lag Screw Withdrawl
T-4	0.4304	11.2	2344	0.7110	Lag Screw Withdrawl
T-5	0.4373	11.6	2332	0.6562	Lag Screw Withdrawl
Average			2646		



Photo 1: Tensile Load (pre-test)



Photo 2: Tensile Load (post-test)



Compressive (Down Force) – Block Without Teeth

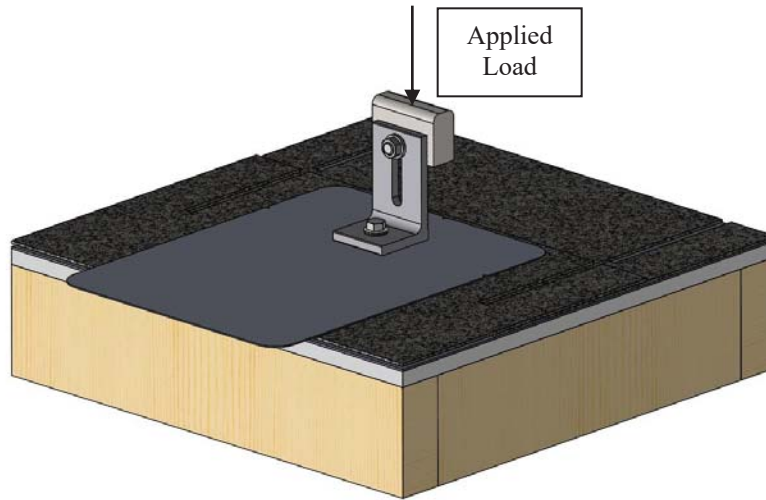


Figure 3: Compressive Load – Block Without Teeth

Sample Number	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
C-SB-1	0.5527	11.4	1172	0.3932	Block to L-Foot Bolt Connection Slipped
C-SB-2	0.4422	11.5	1690	0.4470	L-Foot Bending (Al Ductile)
C-SB-3	0.5451	11.1	1457	0.4330	L-Foot Bending (Al Ductile)
Average			1440		



Photo 3: Compression Load (Block without Teeth, pre-test)



Photo 4: Compression Load (Block without Teeth, post-test)



Compressive (Down Force) – Block With Teeth

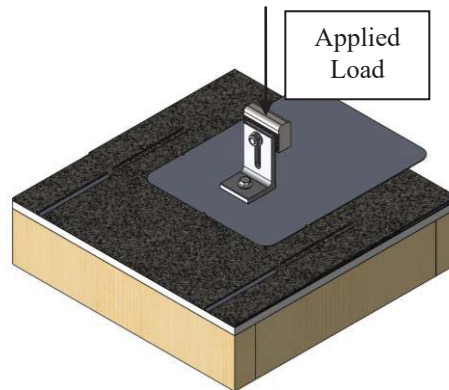


Figure 4: Compressive Load – Block With Teeth

Sample Number	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
C-BWT-1	0.4309	11.1	1288	0.4227	L-Foot Bending (Al Ductile)
C-BWT-2	0.4880	11.4	1752	0.3935	L-Foot Bending (Al Ductile)
*C-BWT-3	0.5382	12.3	2250	0.4650	L-Foot Bending (Al Ductile)
C-BWT-4	0.5813	12.2	1386	0.3357	L-Foot Bending (Al Ductile)
C-BWT-5	0.5873	12.1	1566	0.3819	L-Foot Bending (Al Ductile)
C-BWT-6	0.5332	11.7	1774	0.3207	L-Foot Bending (Al Ductile)
C-BWT-7	0.5336	12.3	1560	0.4689	L-Foot Bending (Al Ductile)
C-BWT-8	0.4753	11.2	1429	0.3802	L-Foot Bending (Al Ductile)
Average			1536		

*C-BTW-3 was set-up with the applied load located closer to the outer edge of the block, away from the horizontal leg of the L-Foot. This resulted in an ultimate load of 2,250 lbs. with an aluminum ductile failure (L-Foot Bending) near the top of the slot. All other tests displayed aluminum ductile failure (L-Foot Bending) at the bottom of the slot. Due to the change in set-up, results were not included in the average.



Photo 5: Compressive Load (Block with Teeth, pre-test)



Photo 6: Compressive Load (Block with Teeth, post-test)



Lateral (Parallel to Rafter) - Downslope

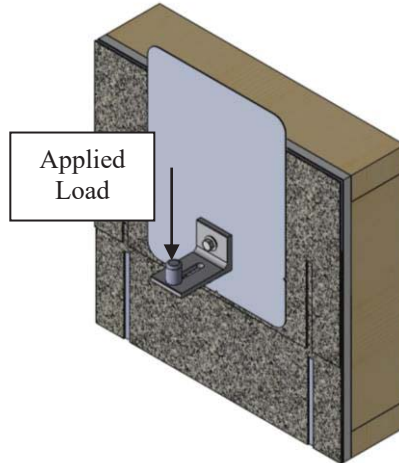


Figure 5: Lateral (Parallel to Rafter) - Downslope

Sample Number	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
DS-1	0.5242	12.3	690	0.7043	L-Foot Bending (Al Ductile)
DS-2	0.4151	11.2	663	0.8495	L-Foot Bending (Al Ductile)
DS-3	0.5481	11.1	665	0.8645	L-Foot Bending (Al Ductile)
DS-4	0.4937	12.0	661	0.6702	L-Foot Bending (Al Ductile)
Average			670		



Photo 7: Lateral Parallel to Rafter Eccentric Load (pre-test) - Downslope

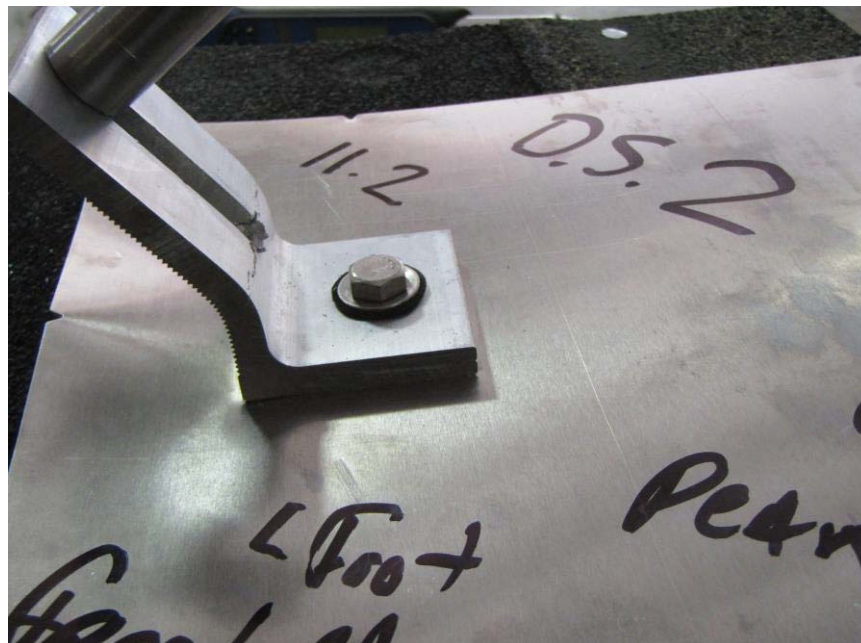


Photo 8: Lateral Parallel to Rafter Eccentric Load (post-test) - Downslope



Lateral (Parallel to Rafter) - Upslope

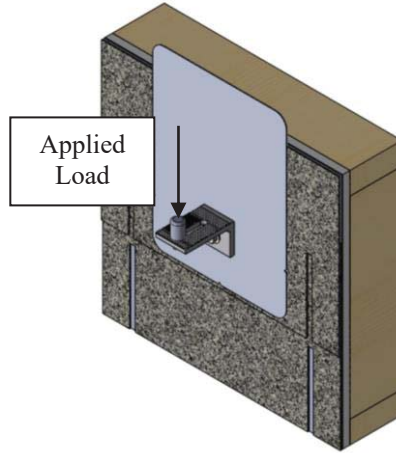


Figure 6: Lateral (Parallel to Rafter) - Upslope

Sample Number	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
US-1	0.5062	11.0	560	1.5978	L-Foot Bending (Al Ductile)
US-2	0.4702	12.2	563	1.4447	L-Foot Bending (Al Ductile)
US-3	0.5289	12.5	564	1.4927	L-Foot Bending (Al Ductile)
US-4	0.4823	11.5	570	1.7931	L-Foot Bending (Al Ductile)
US-5	0.4657	11.5	500	2.1948	L-Foot Bending (Al Ductile)
US-6	0.6680	12.3	603	1.4815	L-Foot Bending (Al Ductile)
Average			560		



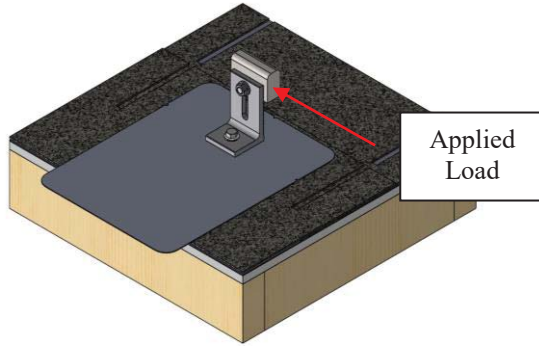
Photo 9: Lateral Parallel to Rafter Eccentric Load (pre-test) - Upslope



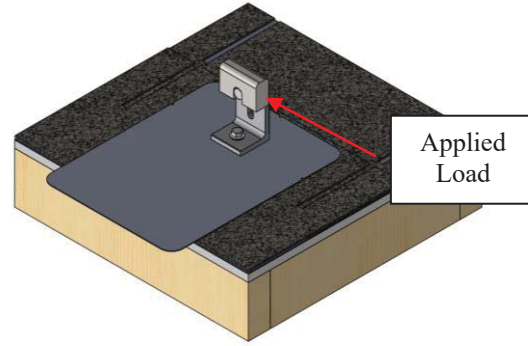
Photo 10: Lateral Parallel to Rafter Eccentric Load (post-test) - Upslope



Lateral (Perpendicular to rafter)



CS-1 to CS-3



CS-4 to CS-6

Figure 7: Lateral Perpendicular to Rafter Eccentric Load

Sample Number	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
CS-1	0.4689	11.6	649	1.6990	Flashing Puncture/Lag Screw Pullout
CS-2	0.5289	12.1	769	1.2980	Flashing Puncture/Lag Screw Pullout
CS-3	0.4648	12.2	752	1.7380	Flashing Puncture/Lag Screw Pullout
CS-4	0.4396	11.5	746	1.1972	Flashing Puncture/Lag Screw Pullout
CS-5	0.4398	12.3	832	0.9692	Flashing Puncture/Lag Screw Pullout
CS-6	0.4387	12.0	871	1.1164	Flashing Puncture/Lag Screw Pullout
Average			767		

Note: CS-1 to CS-3 had the block positioned on the outside of the L-Foot. CS-4 to CS-6 had the block positioned on the inside of the L-Foot.



Photo 11: Lateral Perpendicular to Rafter Eccentric Load (pre-test) – Block Outside



Photo 12: Lateral Perpendicular to Rafter Eccentric Load (post-test) – Block Outside

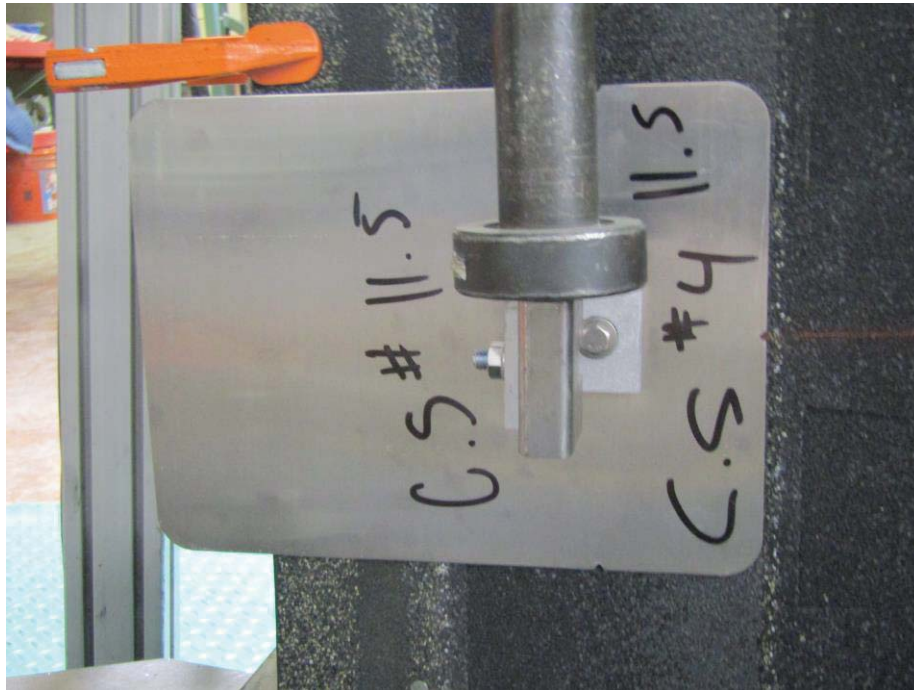


Photo 13: Lateral Perpendicular to Rafter Eccentric Load (pre-test) – Block Inside

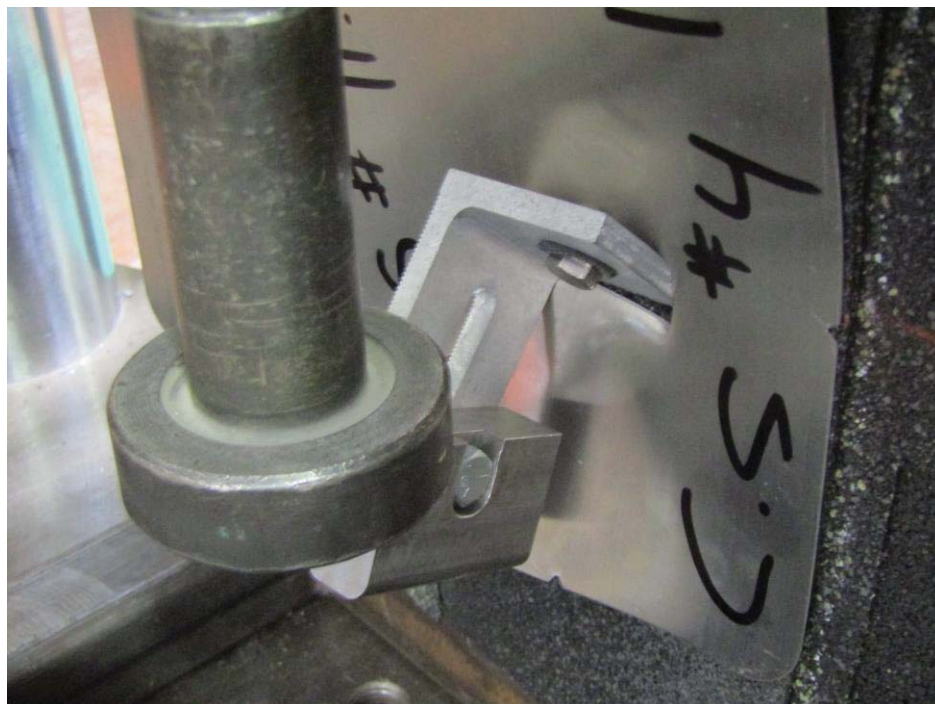


Photo 14: Lateral Perpendicular to Rafter Eccentric Load (post-test) – Block Inside



Installation Drawings

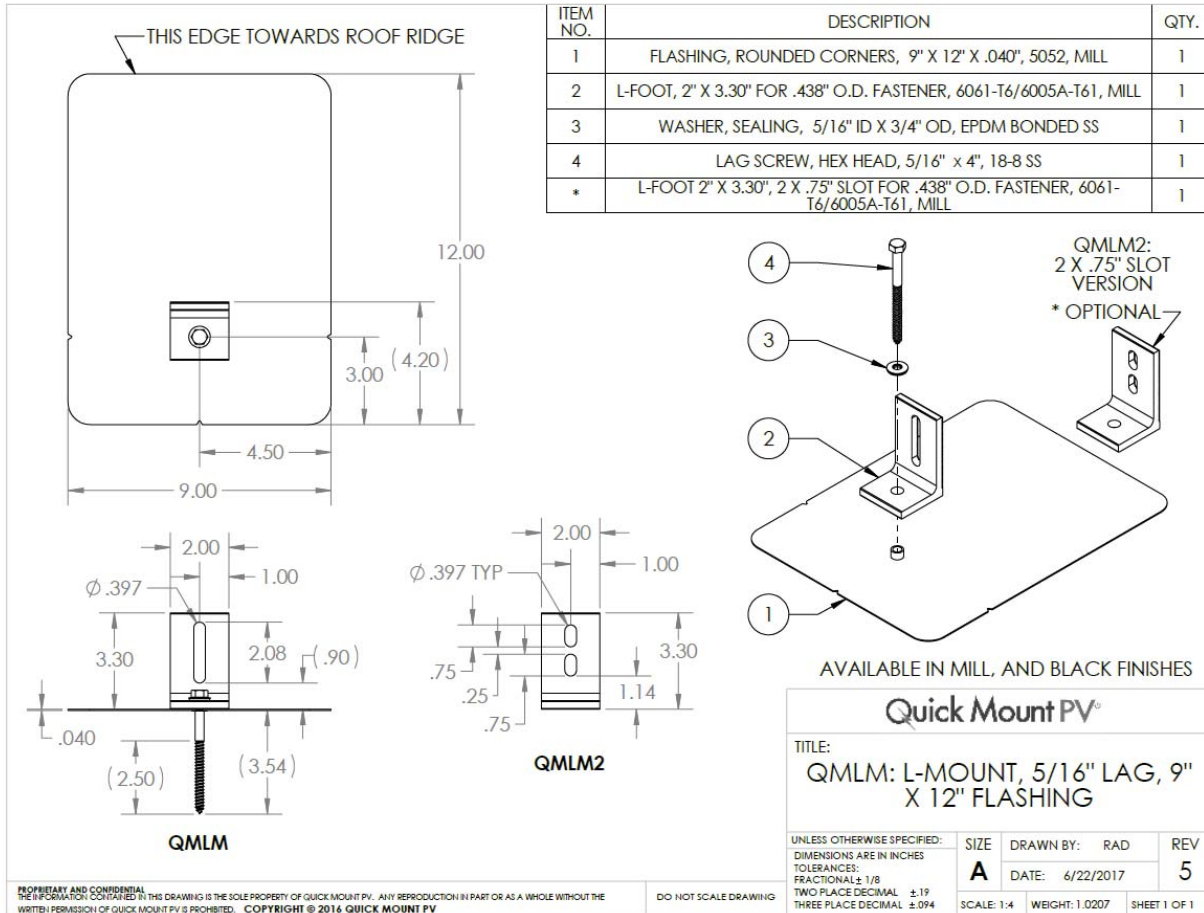


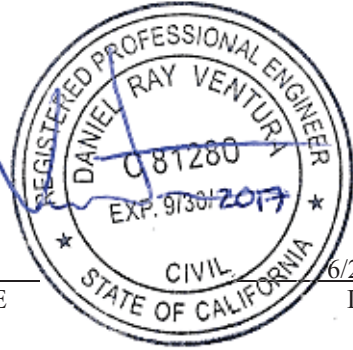
Figure 8: Installation Drawing



CONSTRUCTION
TESTING SERVICES

- TESTING
- INSPECTION
- ENGINEERING

Limitations: Testing was conducted in general accordance with industry standard testing procedures, including ASTM D1761-12, D2395-14, and ICC AC13. The data provided is the result of those tests. CTS assumes no liability and makes no warranty, expressed or implied, as to the usefulness of any information, product, apparatus, or process disclosed.



Reviewed by Daniel Ventura, PE
Associate Engineer

6/22/2017
Date

Technical Contact: **Timothy Casey, Senior Engineer (tcasey@cts-1.com)**
Administrative Contact: **Yolanda Deras (yderas@cts-1.com)**